Abstract

Plasma actuators are devices which function by creating a discharge in air at atmospheric conditions. These devices have been demonstrated to effectively delay flow separation and enhance the lift- drag characteristics of wing sections. They have also been shown to have potential applications in controlling dynamic stall, flow separation control over turbine blades, flow vectoring, boundary layer manipulation and bluff body flow control.

This study examines the characteristics of the plasma actuator, its working and the optimization of its configuration for its use as a lift enhancing device. A single actuator connected to a high-voltage, high-frequency power supply was studied in quiescent conditions. It was demonstrated by means of flow visualization experiments and hot-wire anemometry that the plasma actuator functions by inducing a flow, thus behaving as a source of momentum flux in any system that it is introduced into. Further, it was inferred that the flow induced is a wall jet and that the magnitude of the velocity achieved is maximum within a few millimeters of the surface of the actuator.

A parametric investigation of the actuator was conducted next. The variation of the peak velocity induced in quiescent conditions with the variation of configuration parameters was studied by means of photographic studies and hot-wire anemometry. These experiments indicated that there is a strong correlation between the visible extent of the plasma along the direction of the induced flow (plasma width) and the peak velocity achieved. The peak velocity achieved is found to increase with the increase in the plasma width as long as the discharge created is in the uniform glow discharge regime. The development of

localized high intensity streamers, which destroy the uniformity of the plasma, lead to a loss in the peak velocity.

Hot-wire tests indicated that the peak velocity increases with a decrease in the spanwise overlap of the electrodes, with the other parameters kept constant. Also, in the uniform glow discharge regime, the velocity increases with the increase in the thickness of the dielectric placed between the two electrodes. After a particular optimum thickness, further increase of the thickness leads to formation of streamers. The velocity increased with a decrease in streamwise overlap, with the maximum being reached for a overlap of approximately 2mm, after which it remained a constant. It was observed that the absence of overlap leads to a loss of uniformity of the discharge created. The velocity was found to be independent of the variations in the electrode widths. Particle Image Velocimetry (PIV) was conducted to study the characteristics of the jet produced. It was observed that when the actuator is switched on, a low pressure region is created near the surface of the actuator, vertically above it, leading to a flow towards this region from above the actuator. Furthermore, a vortex is shed, which is convected downstream, after which a wall jet is established close to the dielectric surface.